XI. *An Account of the Organic Chemical Constituents or Immediate Principles of the Excrements of Man and Animals in the Healthy State. By* W. MARCET, *M.D., F.C.S., formerly President of the Edinburgh Medical Society, Corresponding Member of the Société de Biologie of Paris, and Member of the Parisian Medical Society. Communicated by* FRANCIS MARCET, *Esq., F.R.S., Geneva.*

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THE following investigations on the immediate principles which constitute the evacuations of Man and animals were undertaken with the view of endeavouring—

1st. To determine some of the modifications which the unabsorbed part of food undergoes in the alimentary canal.

2nd. To obtain an insight into the nature of the secretions yielded by the glands and mucous membrane of the colon and rectum.

3rd. To extend our pathological knowledge, and afford new means of diagnosis, by applying a method of analysis to healthy human evacuations, thus affording to physicians and pathologists an opportunity of examining these matters in a morbid state.

I had proposed, in the first instance, to confine my researches to healthy human evacuations, but having detected a method of analysis which enabled me to obtain several of their immediate principles in the pure state, I was induced to continue the investigation with reference to the castings of various *carnivorous*, *herbivorous*, and *granivorous* animals. The castings of the Tiger, Leopard, Dog, Crocodile, and Boa were first examined. Then those of the Dog (fed upon bread), Horse, Sheep, Wild Boar, Elephant, and Monkey; and, lastly, the castings of Fowls.

1. *Of the Healthy Human Evacuations.*

The results obtained from the study of the nature and composition of healthy human evacuations, together with the method of investigation employed, have been condensed into a synoptic table annexed to the present communication.

It is superfluous to dwell upon the odour, colour and consistence of human fæces; their reaction is constantly alkaline, and they yield but a very weak extract to distilled water. This alkaline reaction is common to the castings of every animal, and is very probably owing to the presence of ammoniaco-magnesian phosphates, the only strongly alkaline immediate principle which I have obtained from excrements, and which, being soluble, though sparingly, in hot water, is the cause of their alkaline nature.

When boiled in alcohol, human fæces yield an abundant extract, and if small quantities of alcohol be used at a time, and the extract rapidly filtered through a rough, clean cloth, nothing remains on the filter but a brown mass, devoid of smell, insoluble in ether, and yielding to boiling water nothing but ammoniaco-magnesian phosphates, which can be obtained crystallized by slow evaporation.

It was found necessary to operate each time on the whole evacuation, which was treated with boiling alcohol of specific gravity 845 : upwards of fifty human evacuations were examined, about a pint and a half of alcohol being required for each operation; the fæces were previously mixed with a little water, to facilitate the action of the alcohol when their consistence was too solid. This alcoholic extract had a very distinct smell of the matter examined, and a strong acid reaction, showing that one or more acid principles exist as constituents of human evacuations. The alcoholic solution was set aside for twenty-four hours, when an abundant deposit was found at the bottom of the beaker; the fluid was decanted, and the deposit collected upon a filter. The alcoholic solution still possessed an acid reaction; it had a slightly viscous consistence, and a dark olive-brown colour. This fluid was treated by a variety of processes, which yielded no satisfactory result, until milk of lime having been added, with the view of precipitating the fatty acids it might contain, as I had done on a previous occasion to obtain the fatty acids of the blood*, a distinct precipitate occurred of a yellowish-brown colour, subsiding after a few minutes, and leaving a clear brown straw-coloured fluid; this precipitate was collected, after an hour or two, upon a filter. It had a viscous nature and a yellowish-brown colour. The filtrate was set aside, and the lime precipitate left to dry upon filtering-paper. When the excess of moisture had thus been removed, and the precipitate obtained had become comparatively dry, it was transferred to a small glass phial, and agitated with ether: in some instances I used boiling ether, but soon found it was unnecessary, so that cold ether was generally employed. The contents of the phial were next filtered, and a clear yellow ethereal solution thus obtained. The lime precipitate was then washed with ether, and the entire solution finally allowed to evaporate spontaneously. After a period varying from one to three days, the fluid was found to contain a quantity of beautiful silky crystals, collected in masses or tufts adhering to the sides and bottom of the beaker, gradually increasing in size and numbers, and throwing out in every direction extremely fine and light ramifications. The mother-liquid having been decanted, and the substance placed upon filtering-paper, the crystals were found to be so fine and delicate as to be crushed by the mere weight of the fluid contained between them, so that, when dry, their crystalline structure had nearly disappeared, the substance having assumed the appearance of light flattened brittle scales. The crystals thus obtained are far from pure, being mixed with an oily yellow matter, which

* Recherches sur la Nature des Graisses qui se trouvent dans le Sang. Bibliothèque Universelle de Genève, 1851.

proves most difficult to remove. By redissolving them, however, in ether, and allowing the solution to evaporate spontaneously, the substance may be obtained comparatively pure, though not always colourless. I have obtained a nearly colourless solution by filtering the fluid through very finely divided animal charcoal. The crystals obtained from this second solution were generally very much larger than in the previous case, especially when a little alcohol had been added to the ether. These crystals, when viewed under the microscope, were seen to consist of acicular four-sided prisms; they were collected upon a filter, dried and preserved.

This constituent of human evacuations, which I propose to call *excretine*, was detected in every case of healthy human fæces examined; it can be obtained very easily by the above process, even from a small sample of excreted matter, and recognized at once by the silky and very light nature of the tufts.

It is very soluble in ether or hot alcohol, but sparingly so in cold alcohol, and does not precipitate or crystallize on cooling; its solution in ether and in alcohol has a decided though weak alkaline reaction; it is insoluble in water, both cold and hot.

When suspended in boiling water, excretine fuses into a yellow resinous mass floating on the fluid. If dissolved in this state in ether, it again crystallizes when the solution is sufficiently concentrated. When treated with water containing any of the mineral acids, no decomposition ensues, even if the fluid be evaporated nearly to dryness; nothing is obtained but the above resinous mass, which again yields crystals of excretine when dissolved in ether; excretine does not therefore apparently combine with mineral acids. When heated upon a platina knife, the crystals first fuse, evolving a peculiar aromatic smell; they afterwards burn with a slight flame, disappearing very rapidly, and leaving a brown stain, which, on the further application of heat, is completely removed, and no inorganic residue is left behind. The fusing-point of excretine was constantly found to be between 95° and 96° Centigrade.

If excretine be boiled for several hours in a solution of potash, no saponification takes place; the fused crystals float on the fluid, and if dissolved in ether, the substance can again be obtained crystallized.

The elementary quantitative analysis of excretine and the products of its decomposition will constitute the subject of a future inquiry. With respect to its qualitative composition, I have detected *sulphur* as one of its constituents, by calcining a sample of well crystallized and perfectly white excretine with a mixture of carbonate of soda and potash previously ascertained to contain no sulphuric acid. The calcined mass having been dissolved in water acidulated with pure nitric acid, the addition of chloride of barium caused a distinct precipitate. I have also ascertained, by the method of Will and Varrentrapp, that excretine contains a small quantity of nitrogen.

I have not yet investigated the products of decomposition of excretine, but if nitric acid be added to a hot solution of this substance in alcohol, a brisk action

ensues, nitrous acid fumes are evolved, and by concentrating the fluid on the water-bath, another substance is obtained, under the form of beautiful colourless crystals shooting from one side of the capsule to the other, and presently filling up the whole space the fluid occupied. This substance has a strong acid reaction, and is very soluble in water; it attracts rapidly moisture from the atmosphere and deliquesces. However, although it may be interesting in a chemical point of view, as it is not a constituent of excrements, I shall not dwell any longer for the present upon its properties.

It was a matter of considerable importance to ascertain in what form excretine exists as a constituent of human fæces, and if this substance is one of their immediate principles. I have scarcely any doubt as to the greater proportion of excretine existing in the free state as a constituent of excrements, and therefore constituting, in that form, one of their immediate principles, as in several cases I have observed excretine crystallize directly in the alcoholic extract of fæces before the addition of lime. Moreover, although the lime precipitate generally yields, besides this substance, an organic acid which I have found to be margaric acid, it is hardly possible to suppose that lime could have the property of so rapidly decomposing a combination of margaric acid with excretine, should such a compound really exist. I have also ascertained by direct experiment, that if lime be added to a solution of margaric acid and excretine in alcohol, both are precipitated, the margaric acid combining with the lime, and the excretine adhering mechanically to the precipitate formed. It may consequently be assumed that the greater proportion, if not the whole of the excretine contained in human fæces, exists in the uncombined state, or as one of their immediate principles.

Nothing positive is yet known in regard to the mode of formation of excretine in the human body. It may, however, be surmised that it is dependent in some degree on the nature of the alimentation; at least I have noticed an excess of excretine when a considerable amount of beef had been taken, and, on the other hand, a smaller amount than usual of that substance was obtained in a case of diarrhœa attended with loss of appetite. Age and temperament do not appear to modify the production of excretine.

In order to determine the source or mode of formation of excretine in the human body, and complete its physiological history, it will be necessary to ascertain—

1st. Whether it exists in animal food or muscular tissue.

2nd. In what part of the intestines it is first to be detected.

3rd. Whether it can be found in any other part of the human body.

4th. Whether it exists in the castings of animals.

1st. With the view of ascertaining whether animal food or muscular tissue contained excretine, a sample of fresh beef, free from fat, was carefully minced, and treated with boiling alcohol; a colourless extract was obtained, which being filtered through calico, and allowed to stand for some hours, yielded but a very scanty

deposit. Milk of lime produced in this extract a white precipitate, which was collected upon a filter and treated with ether. After twenty-four hours this ether gave by spontaneous evaporation small round translucid masses adhering to the sides and bottom of the beaker, which, when examined under the microscope, were found to consist of round groups of crystals radiating from a centre, and so densely crowded that they could not be distinctly seen unless previously crushed. Small dark specks were mixed here and there with the crystals, but no globules of oil were perceptible, although the evaporation of the ether was nearly complete. When pressed between folds of filtering-paper, the substance left an oily stain; if heated on a platina knife, it immediately fused, and burnt with a gentle flame, evolving a smell of burnt fat. No inorganic residue remained on the platina knife after incineration. The crystals polarized light readily and beautifully; when allowed to dry upon the slip of glass placed under the microscope, they completely lost their distinct structure. No further examination of this substance was attempted, but the characters above-mentioned are sufficient to show, that though in some respects not unlike excretine, it differs from that substance by its fatty nature, and may safely be considered as *stearine*, which it was natural to find in the sample of beef examined.

2nd. The difficulty of obtaining the contents of the human small intestines in the healthy state is so great, that I have not yet been able to ascertain satisfactorily whether excretine be present or not in that part of the alimentary canal; I could not however succeed in obtaining it from the contents of the small intestines of a man who had died from disease of the heart. In this case the alcoholic extract had a pale brown colour and an alkaline reaction; milk of lime added to it gave a precipitate of a light yellow colour, which on being treated with ether, yielded after four days a white amorphous deposit, but no crystals of excretine could be detected.

3rd. With a view of ascertaining whether excretine was to be found in other parts of the body, the parenchyma of the human spleen was next examined. The first spleen which came under my notice was that of a patient of St. George's Hospital who had died from fever; it was apparently healthy; about a quarter of the organ was washed, minced, and boiled with alcohol; the extract yielded on cooling but a scanty deposit. Lime-water having been added, a precipitate was formed, which was collected upon a filter, and subsequently treated with ether, the solution yielding after two days by spontaneous evaporation a number of shining crystals, which, when examined under the microscope, presented the exact appearance of cholesterine. Two other samples of the tissue of the spleen were examined; the first was obtained in a case where death had occurred from an obstruction of the pyloric orifice of the stomach; the second was extracted from the body of an old woman who had died from ascites, accompanied by malignant disease of the ovaries and uterus; this spleen was congested, very friable, and coarsely granulated. In both cases I obtained the same crystalline substance as in my first experiment. It was

found to have the following properties. When obtained directly from its solution in ether, the crystals consist of large, rectangular plates, which, when viewed with the naked eye, floating in the mother-liquor, have the appearance of light shining crystals with a pearly or silky lustre. When collected upon a filter, they rapidly lose their shining nature, which is not the case with cholesterine. Like cholesterine, however, they are insoluble, or very sparingly soluble in cold alcohol, but dissolve readily in hot alcohol, from whence the substance again crystallizes on cooling. The crystals thus obtained still possess the same silky shining lustre as in the previous case, but when subjected to the microscope are found to have lost their rectangular shape, and to have assumed various irregular forms, resembling flies or butterflies with extended wings; they still polarize light very readily. If a few of them be dissolved in a comparatively large amount of alcohol, the substance assumes, on crystallizing, remarkably curious and beautiful forms. Its alcoholic solution has a slightly alkaline reaction; its fusing-point is very high, above 100° Centigrade.

The substance just described cannot possibly be mistaken for excretine, and I should be inclined to consider it as a new immediate principle, unless further investigation should show its complete analogy with cholesterine. It must at all events act an important part in the functions of the spleen, from its having been ascertained to exist as one of the immediate principles of this organ in every case where the spleen was subjected to examination.

Among the intestinal secretions, I have only examined bile (oxen's bile), which yielded no excretine, but only cholesterine, from which circumstance it may be inferred that the method employed for obtaining excretine may also be made use of with advantage to extract cholesterine from its solutions. Indeed, bile contains so small a quantity of cholesterine, that this principle cannot easily be obtained by the usual method, except by operating upon a very large quantity of fluid.

Excretine was not detected in healthy human urine treated by the same method; the lime precipitate, carefully washed with water in order to separate every trace of urea, yielded no perceptible extract to ether.

Blood, human bile, the cerebral and osseous tissue, pancreatic juice, saliva, gastric juice, &c., have not yet been examined in order to ascertain whether they contain excretine. If further experiment shows that this substance can be obtained in no other case than in that of the intestinal evacuations, its formation must evidently result from a metamorphosis or decomposition owing to the action of the solid ingesta upon the intestinal secretions.

From the singular circumstance that excretine contains sulphur, it is not unlikely that the formation of this immediate principle may depend upon a decomposition of taurine, the only sulphuretted compound which, with the exception perhaps of a very small quantity of cystine, can be obtained from the intestinal secretions. Another and very important conclusion resulting from the presence of sulphur in excretine, is, that sulphur is thus eliminated from the body without undergoing

oxidation. The sulphur contained in the body is therefore evidently not all oxidized, and it is not impossible that a large proportion of the sulphur existing in the organic compounds of the body may by this means be eliminated from the animal economy.

The precipitate obtained by the addition of milk of lime to the alcoholic extract of human evacuations having been thoroughly washed with ether in order to separate the whole of the excretine, still generally yields to water or alcohol, when treated with hydrochloric acid, a fatty substance having an acid reaction. The characters of this substance, evidently an important constituent of the human evacuations, are precisely those of margaric acid; by combining with the lime added to the alcoholic extract, it is precipitated along with the excretine and colouring matter. To obtain it, two methods may be employed:—1st. The lime precipitate, deprived of its excretine, is mixed with alcohol, and heated on the water-bath with hydrochloric acid until the whole is dissolved. The acid fluid, on cooling, deposits a mass of crystals, which are collected upon a filter; the filtrate containing the colouring matter, which is set free by the action of the acid, has now assumed a dark red appearance. 2nd. The lime precipitate, deprived of its excretine, is suspended in water and decomposed by hydrochloric acid, with the aid of a gentle heat. By this means it is converted into chloride of calcium, and the insoluble fatty acid being set free is found floating in the liquid. Thus obtained, it has a dirty red colour, and no crystalline appearance; it is next collected upon a filter, and dissolved in hot alcohol; still it does not crystallize on cooling; but if a small quantity of water be added to the solution until a muddiness be induced, and heat again applied, the alcohol on cooling will deposit a crystalline substance identical with that obtained by the former process. If an excess of water be added, with the application of heat, this same substance is deposited in an amorphous form, but may be again obtained crystallized by the same process.

The fatty acid obtained from the lime precipitate was found to have the following properties:—It is soluble in ether and in hot alcohol, but insoluble in cold alcohol; its solution has a distinct acid reaction. When dissolved in hot alcohol, it does not precipitate or crystallize on cooling. It is entirely insoluble in water, and precipitated if water be added to its alcoholic solution; by heating the mixture the precipitate redissolves, and crystallizes on cooling. In its crystalline state it is colourless, has a light consistence and a pearly lustre; the crystals cannot be distinguished by the naked eye, but when examined with a microscope, they exhibit the peculiar structure of margaric acid; some have an arborescent appearance, while others consist of round masses of crystals radiating from the centre, their peripheral extremities being curved in a peculiar manner, and bearing a striking resemblance to margaric acid. If exposed for some time to the air, suspended in water, or in a mixture of water and alcohol, their structure becomes indistinct. When heated upon a platina knife they fuse, evolve a peculiar smell and thick fumes which burn with a flame, and a

dark stain is left on the previously polished platina; this stain finally disappears, leaving no residue. They were found to be capable of combining with hydrated oxide of lead, the compound being insoluble in ether. The salt of lead, previously washed with ether in order to remove the oleate of lead, should any be present, and then decomposed by sulphuric acid, yielded to the ether an acid solution, which, after being thoroughly washed with water in order to separate the free sulphuric acid, and then evaporated spontaneously, deposited a colourless crystalline substance. This substance was dried under the air-pump over sulphuric acid, then fused on the water-bath and introduced into a capillary tube, when on cooling it again assumed the crystalline state. Its fusing-point was found to be 52° Centigrade, a temperature inferior, it is true, to that of 60° required for the fusion of margaric acid; the difference I believe to be owing to a trace of oleic acid, which remained mixed with the crystals. The small quantity of the substance left after the above manipulation, prevented me from having recourse to repeated crystallizations, the only process by which the fatty acids can be obtained perfectly pure.

The characters of the fatty acid which I have just described so completely agree with those of margaric acid, that no doubt remains in my mind as to the complete identity of the two substances *.

As an additional proof of its presence, a sample of pure margaric acid, which I happened to have prepared on a previous occasion, was dissolved in hot alcohol and lime-water added to the solution, a compound of lime and margaric acid precipitated and was collected upon a filter; the precipitate, suspended in alcohol, was decomposed and dissolved by hydrochloric acid, aided by the application of heat, and on cooling, the margaric acid was obtained crystallized. I afterwards ascertained that margaric acid was endowed with the singular property of crystallizing from its solution in alcohol, when the liquid is heated with just enough water to make it become turbid when cold. This circumstance is also a proof that the above fatty acid obtained from human evacuations is not stearic acid, as a sample of pure stearic acid treated by the same process could not be made to crystallize. The solution retained its muddy appearance, the addition of a large amount of water causing an amorphous indistinct precipitate.

It is not possible to state whether a small quantity of the margaric acid obtained by the above process does not exist in the form of a compound as a constituent of human fæces, but from the very acid reaction of the alcoholic extract of excrements, it appears most probable that the whole of this fatty acid exists in the free state in human fæces as one of their immediate principles. I hope, at all events, to have proved satisfactorily that margaric acid is to be found, though not constantly, in the human fæces; and from the circumstance of my never having detected margarine as one of their constituents, I may be allowed to conclude that a process similar

* According to LEHMANN, margaric acid has occasionally been detected in solid excrements by means of the microscope.—Physiological Chemistry, vi. p. 108.

to saponification takes place in the intestinal canal, together with the further decomposition of the soap into its acid and base. According to Cl. Bernard, the above saponification occurs in the duodenum by the action of the pancreatic juice, which converts the neutral fats of the food into an emulsion or state fit to be absorbed by the lacteals. If it be considered, moreover, that blood contains free fatty acids, a circumstance first shown by Lecanu, and which I have had myself an opportunity of verifying in Messrs. Wurtz and Verdeil's laboratory at Paris, perhaps we are entitled to admit that the saponification arising from the action of the pancreatic juice upon the neutral fats of food, and the decomposition of the soap, both take place in the duodenum, the excess of free fatty acid which escapes absorption being carried through the intestinal canal, and expelled with the evacuations. If a powerful free acid were found to exist in the blood, it might be supposed that the fatty matters saponified by the pancreatic juice are absorbed, the soap decomposed in the circulation, and the excess of free acid which could not be assimilated, conveyed into the intestines by the intestinal secretions; but as the blood contains no powerful free acid, being, on the contrary, constantly alkaline, this theory cannot be maintained.

I have not yet been able to ascertain with any degree of certainty whether stearic acid be present or not in human evacuations; but if it be considered that margaric acid is habitually found in them, and sometimes even in large quantities, although the fats contained in the mutton and beef taken as food were nearly pure stearine, and if the transformation of stearic acid into margaric acid must take place somewhere in the body, human fat consisting mainly of margarine, are we not entitled to conclude that this stearine is converted into margaric acid during its passage through the intestinal canal?

The third substance present in human excrements, which may be obtained from the lime precipitate, is the *colouring matter*. If this precipitate, deprived of its excretine, be dissolved in alcohol with hydrochloric acid, a dark port-wine-coloured solution is produced, which on cooling deposits margaric acid; the filtrate contains the colouring matter free from this acid. By adding water to the solution, and concentrating it on the water-bath, the colouring matter separates in the form of flakes floating on the fluid, and leaving a nearly colourless mother-liquor. The substance is now collected on a filter, dissolved with hot ether, and the solution washed with water in order to remove the last traces of hydrochloric acid. The ethereal solution, mixed with water and allowed to evaporate spontaneously, deposits the colouring matter in the form of a dark brown or black amorphous substance, exactly similar to the colouring matter extracted by Dr. Verdeil from the blood, and to that which Dr. Harley has lately obtained from urine, with which it appears identical.

I have already alluded more than once to a precipitate or deposit occurring in the alcoholic extract of healthy human evacuations, which appears to be of a very com-

plex nature. If the above alcoholic extract after having stood for twenty-four hours be decanted, and the precipitate collected at the bottom of the beaker thrown upon a filter, the deposit presents an olive-brown appearance, a strongly acid reaction, and the fœtid smell peculiar to fæces. When viewed under the microscope, it appears to consist principally of small oily globules, of a yellow-green colour, having a strong refracting power, and mixed sometimes with crystals of excretine accompanied by a yellow amorphous deposit. This deposit invariably occurred in every healthy human evacuation that I examined. After a few hours, it had assumed a gelatinous consistence; if it was then boiled with alcohol in a capsule or a glass flask as long as it yielded anything to that fluid, and finally filtered through white calico, a substance was left behind, insoluble in boiling alcohol. This substance, when heated upon a platina knife, first fuses, then burns with a flame evolving an oily smell, and leaves a residue of white ashes. The alcoholic filtrate from the above substance, after having been allowed to stand for twenty-four hours, yielded a deposit which fell to the bottom of the beaker; the whole was next thrown upon a filter, thoroughly washed with cold alcohol, and the washings together with the filtrate concentrated on the water-bath. The solid substance remaining on the filter was then washed with ether and yielded an ethereal solution of a yellow colour and very acid. The residue was of a light yellow colour, and, when viewed under the microscope, appeared to consist of an amorphous mass free from globules; dried on filtering-paper, it became nearly colourless and of a light friable nature. When heated on a platina knife, it first fused and assumed a dark colour, emitting a smell of burning oil; it afterwards burnt with a bright fuliginous flame, and finally left a residue of porous white ashes, consisting of phosphate of potash. It did not dissolve in boiling water, but fused and floated on the surface; it was also insoluble in cold alcohol, and when suspended in that liquid sunk very slowly to the bottom, appearing to have nearly the same specific gravity. It is soluble in boiling alcohol, and on cooling is again precipitated. It is very sparingly soluble in cold ether, but becomes more so when heat is applied.

I have not yet sufficiently examined the properties of this substance to be able to determine whether it is a pure immediate principle; indeed, from my having failed in my endeavours to obtain it crystallized, it might be regarded as a mixture of several principles. The above-mentioned properties, however, are distinctly defined, and under all these circumstances, I am inclined to consider it as a combination of phosphate of potash and a purely organic substance.

The ethereal extract obtained from the above substance deposits by spontaneous evaporation a crystalline matter, which has not yet been obtained in sufficient quantity to admit of its being examined.

The clear cold alcoholic solution obtained from the olive-coloured acid deposit, or the filtrate from the substance just described, having been evaporated down on the water-bath, yielded a deep olive-coloured oil, quite fluid when warm, and emitting

the smell peculiar to fresh evacuations. With the view of obtaining it pure, I first dissolve it in ether, in order to remove a solid granular substance of a light consistence, insoluble in ether and in cold alcohol, but dissolving readily in hot, and forming a solution which yields, when concentrated, a number of round globules. These when heated upon the platina knife, fuse, and then burn, evolving a smell of burnt meat, and leaving behind a residue difficult to incinerate; but not having succeeded in obtaining this substance in a crystallized state, I cannot say more at present as to its properties. The oil deprived of the above granular substance, and dissolved in ether, was mixed with alcohol, and subsequently lime-water was added; the mixture was then heated upon the water-bath, until a heavy precipitate, consisting of a compound of this oil with lime, had been deposited. This precipitate was collected upon a filter, thoroughly washed with hot and cold alcohol, and the filtrate set aside. The insoluble salt of lime obtained was now decomposed with sulphuric acid, and treated with ether, in order to separate its organic constituent. The ethereal solution was then well washed with water, to get rid of the sulphuric acid it contained, and when evaporated down on the water-bath, yielded a pure fatty substance having a constant fusing-point. This substance, dried over sulphuric acid at the temperature of the atmosphere, is solid, but fuses invariably between 25° and 26° Centigrade, showing it to exist in a pure state. When heated on a platina spatula, it first fuses, evolving a smell somewhat resembling that of excretine; it next takes fire and burns with a bright flame, which disappears as soon as the platina foil is removed from the lamp; a black stain remains, which, by further application of heat, is completely removed. When boiled with a solution of caustic potash, the substance does not dissolve, but floats on the surface of the liquid. It is insoluble in water, but very soluble in ether, sparingly so in cold alcohol, but dissolving readily in hot, and not precipitating on cooling. Its solution possesses a marked acid reaction.

It is not easy to determine whether this chemical compound, which I propose to name *Excretoleic acid*, is, or is not an immediate principle of human fæces. I am inclined to believe that it exists in them as an acid salt, the base being excretine, or a substance whose properties exactly resemble those of excretine, except that it fuses apparently at a lower temperature. This base is obtained in the filtrate from the precipitate which occurred when milk of lime was used to purify excretoleic acid. I have several times found the filtrate, after twenty-four hours, full of a crystalline mass, which, viewed under the microscope, resembled excretine, possessing the same properties of solubility in alcohol, ether, &c., but fusing at a lower temperature, between 70° and 80°, very probably because I had not obtained it in a perfectly pure state. When this substance was not found crystallized in the alcoholic filtrate, it was obtained by evaporating the solution to dryness and taking up the residue with ether, when it crystallized by spontaneous evaporation.

We have already seen that the addition of milk of lime to the clear cold alcoholic

extract of fæces had caused the formation of the precipitate which has been described as composed of *excretine, margaric acid, colouring matter*, and *lime*. The filtrate from this precipitate having been concentrated on the water-bath, a scanty amorphous deposit occurred floating in the solution, which, when viewed under the microscope, showed no crystalline structure. The concentrated fluid allowed to stand for several days, yielded no crystals, but merely an amorphous residue. By distilling it with water in a small retort, a few drops of sulphuric acid having previously been added, I obtained a colourless acid fluid, having a strong smell, resembling that of butyric acid, which I at first considered to be owing to the presence of that substance; but on treating this fluid with lime or baryta, I failed to obtain any crystallized salt, showing that butyric acid was not present, and consequently it cannot be considered as a constituent of human evacuations. The alcoholic extract concentrated on the water-bath was also treated with ether; the ethereal solution obtained, decanted and allowed to evaporate spontaneously, yielded on several occasions crystals of excretine.

From the above investigations, I may conclude that human evacuations in the healthy condition contain:

1st. A new organic immediate principle, having a crystalline structure and an alkaline reaction, which I propose calling *Excretine*.

2nd. A substance possessing the characters of margaric acid, which, though not constantly present in human evacuations, is generally found as one of its constituents.

3rd. A colouring matter analogous to that of blood.

4th. A pure olive-coloured fatty acid, which I propose to call *Excretoleic acid*.

5th. Volatile fatty acids, free, however, from butyric acid.

I shall now endeavour to relate as briefly as possible the circumstances and results which attended the examination of the castings of various animals, the method of analysis which I employed being similar to that already followed for the investigation of human evacuations.

2. *Castings of Carnivorous Animals.*

1st. *Castings of the Tiger.*—Newly-passed Tiger's excrements, obtained from the Zoological Gardens in small lumps, were of a pale colour, had a peculiar nauseous smell, and an alkaline reaction. Having previously been washed with a small quantity of water, they were boiled with alcohol, and yielded a pale-coloured alcoholic extract. The solution, left undisturbed for twenty-four hours, gave no deposit, its reaction was slightly acid; milk of lime added to the extract produced a nearly white precipitate, which, after having been dried upon filtering-paper, was treated with ether, both hot and cold, until nothing more could be separated from it. The

ethereal solution, allowed to evaporate spontaneously, was, after three days, found to contain a quantity of shining crystals, polarizing light under the microscope, and mixed with traces of a red amorphous deposit. The crystalline mass, dried first upon bibulous paper and then under the air-pump, assumed the form of slightly brick-coloured translucent scales. When heated upon a platina knife, they first fused, emitting the peculiar smell of the tiger's den, and when allowed to cool exhibited a yellow waxy appearance, reflecting light powerfully under the microscope, but without any crystalline structure. They burnt with a bright flame, leaving traces of a white inorganic residue, probably from their not being quite pure, and hardly any black stain.

The above substance is insoluble or very sparingly soluble in cold alcohol, but dissolved readily in that fluid when boiling. By concentrating the alcoholic solution on the water-bath, arborescent crystals were obtained which dissolved in cold ether, but not so readily as excretine, and again crystallized if the solution was allowed to evaporate spontaneously. These crystals are very similar to those obtained from the alcoholic solution, but appear to lose their structure more rapidly as the ether evaporates than they do when produced from the evaporation of alcohol.

I am not disposed to consider the above substance, which appears to exist in the castings of all the carnivorous animals I have had an opportunity of examining, as identical with human excretine, which it resembles, however, in many of its properties. It appears to differ from it, first, by the shape of its crystals; secondly, by the smell it emits when burnt; thirdly, by a much less degree of solubility in alcohol and ether.

The filtrate from the lime precipitate was concentrated upon the water-bath, when a whitish-pink sediment was deposited, which, when examined under the microscope, was found entirely composed of small round crystalline masses radiating from a centre. The crystals, collected on a filter and dried, burnt on the platina knife with a bright fuliginous flame, and left a white residue, consisting of lime. This salt of lime was found to be soluble, though not very readily, in alcohol; on adding a few drops of water to the solution it turned milky, and on cooling the whole mass instantly crystallized. The addition of sulphuric acid immediately brought out a strong smell of butyric acid; the salt obtained from this alcoholic extract was therefore evidently *butyrate of lime*. It could not be the lactate, although its crystalline form is similar, as the lactate is exceedingly soluble in water, and can only be made to crystallize in a very concentrated solution, contrary to what took place with the substance obtained from the Tiger, which begins crystallizing long before the solution has attained a high degree of concentration.

I was not able to ascertain whether butyric acid exists in the free state, or combined with a base, as an immediate principle of the castings of the Tiger. It is probable, considering the slight degree of acid reaction shown by the alcoholic extract, that this acid occurs in the form of a salt.

2nd. *Castings of a Dog fed upon meat.*—Fresh castings from a Dog, fed in my laboratory for several months upon meat alone, were next examined. They had an alkaline reaction and a dark brown colour. When washed with a little water and boiled with alcohol, they yielded an alcoholic solution, of a red colour when seen by reflected light and possessed of a slightly acid reaction. Put aside in a beaker for twenty-four hours, very little or no deposit occurred. The extract was mixed with lime-water, which caused the formation of a very light yellow precipitate. I treated it with ether, as in the previous cases, and allowed the ethereal solution to evaporate spontaneously. After four days, a shining crystalline deposit was observed floating in the liquid, which exactly resembled the substance obtained under similar circumstances from the castings of the Tiger. The filtrate from the lime precipitate having been concentrated on the water-bath, was soon observed to be full of crystals floating in the fluid in the form of white masses. When viewed with the microscope, they were found to be elongated prisms irregularly grouped in large masses. Heated upon a platina knife, they burnt with a flame, and left an ashy residue composed of lime. When a drop of sulphuric acid was added to some of the crystals dried on filtering-paper, and heat subsequently applied, a distinct smell of rancid butter, peculiar to butyric acid, was evolved, showing them to be butyrate of lime. After some days, the solution of the salt in alcohol, previously filtered through animal charcoal to remove the colouring matter, yielded by spontaneous concentration a number of perfectly white globular masses of crystals about the size of a large pin's head, which, when dried upon filtering-paper, assumed a beautiful silky appearance. In conclusion, the castings of dogs fed upon meat contain butyric acid, but whether it be in the form of a free acid or of a salt, I have not yet satisfactorily ascertained.

Crocodile's Excrements.—During a visit to the Zoological Gardens, I had an opportunity of obtaining from the crocodile's cage a small quantity of the fresh castings of this animal. They had a peculiar fœtid smell, and when dried could be easily pounded into a white powder, some of which, treated with nitric acid and ammonia, failed to denote the presence of uric acid. The pounded mass, after having been converted into a paste with a few drops of distilled water, and then boiled with alcohol in a glass flask, was thrown upon a calico filter. The filtrate having been a few hours afterwards mixed with lime, a yellow precipitate was thus produced; this precipitate was subsequently filtered and boiled with ether. The filtered ether, left to spontaneous evaporation for a day and a night, yielded a large quantity of broad silky crystals floating in the liquor, which when viewed through a microscope, were found to have exactly the form of *cholesterine*. Heated upon a platina knife, the substance fused and burned with a brilliant flame, like cholesterine, leaving no residue. It had also a light consistence and the pearly lustre of cholesterine, was insoluble in water and in cold alcohol, but soluble in hot alcohol. From the above results, there is every reason to believe that this substance is cholesterine: this immediate principle of the bile is known, moreover, to exist generally

in the castings of hibernating animals. I am not, however, aware whether it has been as yet extracted from those of the Crocodile.

The occurrence of cholesterine in the excrements of the Crocodile, and not in those of the Boa or any other animal which I have examined, is a phenomenon worthy of notice. It may be concluded from it, that a portion only of the bile secreted by the Crocodile is modified or absorbed during digestion, and the rest eliminated with the casting.

Boa.—I treated the castings of the Boa in the same way as those of the Crocodile, but without finding cholesterine. It has already been observed that the above method was applied to the examination of bile, and that cholesterine was obtained; so that had any cholesterine been present in these castings, it could not have escaped observation.

Leopard.—The castings of the Leopard were also examined; the lime precipitate in the alcoholic extract having been treated with ether, and the ether allowed to evaporate spontaneously, yielded a mass of light colourless crystals, readily reflecting light, and resembling those obtained in similar circumstances from the Dog and Tiger, but not mixed with the red amorphous substance.

In conclusion, the castings of the carnivorous mammalia appear to contain the peculiar light crystalline substance, differing in its properties from excretine, and obtained from the ethereal extract of the lime precipitate above described. I have constantly failed to detect excretine as a constituent of these castings.

The excrements of the carnivorous mammalia also contain butyric acid, or some of its salts, while in no case have I been able to obtain this substance from human fæces, where it was thought to exist. There is probably, therefore, some chemical change going on in the intestines of these animals different from what occurs in the human alimentary canal, and the butyric acid, unless it be secreted from the mucous membrane of the intestines, must result from some change which the animal food undergoes in the intestine during the process of digestion. It is not impossible that some of the sugar elaborated by the liver may be converted into butyric acid in the circulation and eliminated through the intestines.

The fæces of the Crocodile and Boa materially differ from each other, the former containing cholesterine, but no uric acid, and the latter being nearly entirely composed of urates, but containing no cholesterine. The rule applied to hibernating animals meets here with an exception; further investigation is therefore necessary before any positive and general law can be arrived at.

3. *Of the Castings of Herbivorous Animals.*

The castings of the *Horse*, *Sheep*, *Dog fed upon bread*, *Wild Boar*, *Elephant*, and *Monkey* were next examined: in no case could I succeed in detecting the presence of excretine or of butyric acid as one of their constituents.

The following are the peculiarities which the examination of those excrements presented:—

Castings of the Horse.—Horse's excrements, boiled with alcohol, yielded but a very scanty deposit on cooling; but the solution, mixed with milk of lime, gave a yellow precipitate of a light homogeneous nature. The ethereal extract from this precipitate, evaporated spontaneously for twenty-four hours, left a yellow residue viewed under the microscope as drops of oil; but not a trace of excretine could be detected. The filtrate from the lime precipitate, concentrated on the water-bath, did not yield any butyrate of lime.

Castings of the Sheep.—Newly-passed castings of the Sheep, washed with a little alcohol and boiled in that liquid, gave a deep green extract, in which milk of lime produced a very abundant green precipitate, the liquid remaining yellow. Thi precipitate, collected on a filter and treated with ether, yielded a dirty dark green solution, which, allowed to evaporate spontaneously, deposited after twenty-four hours a green mass, observed under the microscope to consist of an amorphous and a crystalline substance. The latter, though not distinctly defined, possessed a yellow colour, refracted light very readily, and polarized. No substance resembling excretine was obtained. From the difficulty of separating the above crystalline substance from the green amorphous matter, the investigations on this part of the subject are necessarily imperfect.

The filtrate from the lime precipitate did not yield any butyrate when concentrated.

Castings of a Dog fed upon bread.—The castings of a Dog fed for about a month upon nothing but bread gave a very pale alcoholic extract, yielding but a slight deposit on cooling. The precipitate produced by the addition of lime to this extract was of a yellow colour, and when treated with ether, prismatic crystals were obtained by its spontaneous evaporation, usually grouped three or four together, meeting at one extremity and diverging at the other. Some groups had a less defined character, and resembled leaves converging at one of their extremities; they polarized light beautifully. These same crystals were obtained in one instance from the castings of a dog fed upon meat, of which they are probably merely a modification.

Castings of the Boar.—Fæces from the Wild Boar were procured fresh from the Zoological Gardens, the animal being fed upon biscuit and cabbages. These castings occurred in the form of green masses, having an alkaline reaction. When washed with a little water and boiled in alcohol, they yielded a dark green solution. An abundant deposit occurred on cooling, from which the fluid was decanted. Milk of lime added to the solution produced a yellow precipitate, as in the previous cases. It was treated with ether, which was allowed to evaporate spontaneously. After a week a green deposit was obtained, composed of an amorphous green oil and arborescent crystals, readily polarizing light; they had not, however, the peculiar look of excretine, and did not crystallize in tufts like that substance. The filtrate

from the lime precipitate, concentrated on the water-bath, left a green residue having an oily consistence. Ether being added, dissolved this green substance, which was again deposited by spontaneous evaporation, without assuming a crystalline form. No butyric acid was therefore present.

Castings of the Elephant.—I obtained from the Zoological Gardens a sample of the castings of an Elephant fed with cabbage, hay, oats, and chaff; they occurred in large masses, their consistence resembling that of horses' excrement. When washed with a little water and boiled in alcohol, they afforded an alcoholic extract, which on cooling yielded an olive-coloured deposit. The precipitate obtained by adding lime to the alcoholic solution decanted from the deposit, was of a yellow-brown colour. It was treated with ether, which, after having stood undisturbed for three days, yielded a bulky deposit, presenting no distinct structure when viewed under the microscope. The examination of these castings presented the following peculiarities, which I must not omit noticing. The ether with which the lime precipitate had been boiled having been decanted, deposited, on cooling, a white gelatinous substance, insoluble in cold ether and in alcohol, but which dissolved immediately on the addition of a few drops of hydrochloric acid to the alcohol, and the application of a gentle heat; it again solidified on cooling, giving the whole fluid a semi-solid appearance. Examined with the microscope, it appeared composed of amorphous transparent masses. Pressed between folds of bibulous paper, it assumed a pure pearly aspect, very similar to that of margaric acid. If heated, it fuses very readily, emitting scarcely any perceptible smell, burning with a slight blue flame, and leaving behind a black stain, which, by the further application of heat, completely disappeared, nothing remaining on the spatula.

From the preceding experiments, it appears probable that the substance I have just described is a pure constituent of the Elephant's castings.

Castings of the Monkey.—I treated with boiling alcohol a sample of the castings of the Monkey, obtained from the Zoological Gardens, but could not detect the presence of excretine as one of their constituents. The lime precipitate obtained from the Chimpanzee's excrements, treated with ether, and the ether left to evaporate spontaneously, yielded crystals polarizing under the microscope, and very much resembling in structure those obtained by the same process from the Tiger.

4. *Castings of Granivorous Animals.*

The only castings of granivorous animals I had an opportunity of examining were those of fowls fed with oats. In this case also I could obtain no excretine. The castings boiled with alcohol left an insoluble mass entirely composed of oat-husks; the yellow alcoholic solution, mixed with milk of lime, deposited a yellow precipitate, which yielded to ether a faint yellow solution. After spontaneous evaporation for two days, the ether was observed to deposit an amorphous yellow sediment, which, viewed under the microscope, was found to consist of a mass of

transparent globules, resembling exactly those obtained by the same process from the castings of the Horse. No crystals were deposited by the ethereal solution.

My investigations upon the chemical constituents of the castings of animals show, therefore,—

1st. That they contain no excretine, thus differing very materially from human evacuations.

2nd. That the castings of carnivorous mammalia contain,—(1) a peculiar crystalline organic substance obtained by the same process as excretine; (2) *butyric acid*, existing probably in the form of a salt, as one of their constituents.

3rd. That the castings of the Crocodile yield *cholesterine*.

4th. That the castings of herbivorous animals contain no excretine and no butyric acid, and do not yield the crystalline substance obtained from those of carnivorous animals, except perhaps in the case of the Monkey.

Synoptic Table of the Immediate Principles of Human Evacuations in the Healthy State.

- **Fæces boiled with alcohol.**
  - Substance insoluble in alcohol, consisting of ammoniaco-magnesian phosphate, other inorganic salts, organic fibres, and other parts of food which have escaped absorption.
  - Substance soluble in boiling alcoholic extract, but subsiding as soon as the fluid has become cold. When collected upon a filter and boiled in alcohol, it yields
    - A substance insoluble in boiling alcohol.
    - A substance soluble in boiling alcohol, but precipitating on cooling, which, when washed with ether, yields
      - A pure non-crystallizable substance, soluble in hot alcohol, but precipitating in the solution when cold; not yet sufficiently examined to rank as an immediate principle.
      - A substance soluble in ether, and crystallizing by spontaneous evaporation.
    - A substance soluble in boiling alcohol, and not subsiding in the cold solution. Evaporated to dryness, and treated with cold ether, it yields
      - An olive-coloured acid substance, soluble in ether and in hot alcohol, but not precipitated in the cold solution. Found by the addition of milk of lime, with the application of heat, to consist of two substances, viz.
        - A first substance precipitated by the lime, which decomposed with sulphuric acid, yields to hot ether the pure immediate principle, *Excretoleic acid.*
        - A second substance, dissolved in the hot filtrate from the above lime precipitate, being *Excretine*, or a body closely allied to it.
      - A yellow substance insoluble in ether, and partly soluble in water.
  - Substance soluble in hot alcoholic extract remaining dissolved in the fluid when cold. This solution is treated with milk of lime.
    - Precipitate obtained by the addition of milk of lime to the alcoholic solution.
      - The precipitate treated with ether, and the ethereal solution evaporated spontaneously, yields
        - *Excretine.*
        - A yellow oily matter, hitherto undescribed.
      - Precipitate, free from excretine, dissolved in alcohol or decomposed in water by hydrochloric acid, yields
        - *Margaric acid* (not constantly present).
        - *Colouring matter* of excrements.
    - Filtrate from lime precipitate concentrated to a semifluid consistence.
      - Treated with ether, often yields excretine.
      - Concentrated filtrate, free from excretine, decomposed with sulphuric acid and distilled, does not yield any butyric acid.